

**IMPROVING SCIENCE AND MATHEMATICS INSTRUCTION**  
**AT CAPITAL CITY PUBLIC CHARTER SCHOOL**

Recommendations of the Science and Mathematics Curriculum Committee of the School Planning Team at Capital City Public Charter School, Washington, D.C.

5 August 2009

Science instruction at Capital City Public Charter School is in urgent need of improvement. This and other findings of the School Planning Team's Science and Mathematics Curriculum Committee are presented in this report, along with recommendations for improving instruction.

The report has three sections: background, summary of recommendations, and discussion of recommendations.

**BACKGROUND**

On 3 February 2009, the president of the United States came to Capital City Public Charter School and called upon schools nationwide to make sure "that we're encouraging parents to be involved, that we're raising standards for all children so that everybody can learn -- especially things like math and science."

A few hours later, as camera crews were packing up, the school's School Planning Team held its first meeting of the 2008-09 school year and established a committee to look into improving science and mathematics instruction at the school.

Although it was just a coincidence that the SPT acted immediately after Barack Obama's call, no one should be surprised that a national education issue such as the quality of science instruction is an issue at our school, too.

The SPT Science and Mathematics Curriculum Committee soon grew to 16 members drawn from the ranks of parents, teachers, and students. When we shared with each other our firsthand knowledge of what goes on academically at the school, we found that we had perceived the same problem. One parent summarized it succinctly by saying that the school does not prepare students to go "from art to architecture." Thus, some families have left the school to keep open their children's option for careers in fields (such as architecture) that require excellence in science and math.

Pooling our knowledge and doing further research has led us to make the recommendations listed below. Our research involved visiting classes, reviewing curriculum materials, talking to teachers, talking to administrators, consulting with experts, and checking out practices at other schools. We also reviewed science and mathematics education research. One of our resources was the publications of the National

Mathematics Advisory Panel, a White House-commissioned group that conducted a massive survey of research on mathematics education, focusing on preparation of students to succeed in algebra.

#### SUMMARY OF RECOMMENDATIONS

1. Science should be a "stand-alone" subject like math, reading, and writing, with substantial dedicated time on the weekly class schedules. This would require a significant increase in the amount of time reserved explicitly for science on the weekly class schedules in grades pre-K through 6. The increase should be in place on 1 September 2009, the first day of the 2009-10 school year. The time blocks promised for science should then actually be used for science activities.
2. The school should have a plan for science instruction, as it has for other subjects. Such a plan, known as a "scope and sequence" or "continuum," would prescribe the science knowledge and skills to be taught in each grade. The plan should be at least as comprehensive as the Massachusetts scope and sequence for science and should promise students hands-on experience with a large number of natural phenomena.
3. Teachers should receive a substantial amount of professional development in science and mathematics aimed at increasing their subject-matter knowledge.
4. Students in grades pre-K through 6, and their teachers, would benefit by working with specialist teachers who have deep science and mathematics knowledge. Resource teachers with such knowledge could team with teachers to prepare and deliver lessons and could lead in-service courses for teachers.
5. The school should offer a rigorous algebra 1 course.
6. The school should allow -- indeed, encourage -- acceleration in mathematics, as it does in reading. ("Acceleration" means moving through the curriculum at a faster pace.)
7. In its publications that discuss its curriculum, the school should list calculus explicitly as a course that it plans to offer.
8. Technology is an important subject that deserves greater representation in the curriculum, with an explicit continuum (scope and sequence) of its own. Students should be able to explain in detail how things work.
9. The Everyday Mathematics program, which the school uses through 5th grade, provides a "Family Letter" for teachers to photocopy and send home at the beginning of each unit during the school year. The letter tells parents what math their children will be learning in the unit. The school should make sure that these letters are sent home.

10. The school should incorporate the above recommendations into its forthcoming School Improvement Plan, and make sure that the plan includes science.

#### DISCUSSION OF RECOMMENDATIONS

1. Science should be a "stand-alone" subject like math, reading, and writing, with substantial dedicated time on the weekly class schedules. This would require a significant increase in the amount of time reserved explicitly for science on the weekly class schedules in grades pre-K through 6. The increase should be in place on 1 September 2009, the first day of the 2009-10 school year. The time blocks promised for science should then actually be used for science activities.

Capital City PCS subscribes to the Expeditionary Learning model of instruction, in which students do part of their learning through a semester-long focus on a single theme. (See <http://www.elschools.org>) Thus, each class in grades pre-K through 8 is said to do two "expeditions" per school year.

A wide variety of subjects come up in expeditions: reading, writing, history, civics, math, science, art, and so on. However, expeditions do not cover subjects comprehensively, and so the school allots large blocks of time on the weekly class schedules to subjects that it wishes to cover thoroughly and systematically. For example, the school typically gives math five hours per week of dedicated classroom time. (For reference, our SPT committee has posted the 2008-09 weekly class schedules for Lower School grades pre-K through 8 at the parent listserv website; log in at <http://groups.yahoo.com/group/ccpcs/files> Capital City PCS has two campuses -- a Lower School with one class in each grade pre-K through 8, and an Upper School with one class in each grade 6 through 8 and two classes in each grade 9 and up; the school is adding one grade per year and will be complete with classes through grade 12 in the 2011-12 school year.)

The school should make science one of the subjects that it covers comprehensively and methodically, with significant dedicated time on the weekly class schedules. This would be a big change. In the 2008-09 school year, for example, the 6th graders had only two hours per week reserved for science, and countless times throughout the school year those few promised hours were not used for science activities. The 3rd graders had only one hour per week reserved for science. As many as half of the expeditions involve no hands-on science activity at all, and so relatively little classroom time has been devoted to hands-on science activity. Expeditions should not set limits on the science curriculum, but rather should give students an opportunity to explore a few selected science topics in greater depth.

The lack of sufficient dedicated time for science in grades pre-K through 6 at Capital City PCS has forced teachers to make poor use of the FOSS materials that the school uses for much of its science

instruction. FOSS, or Full Option Science System, is a better than average science teaching program designed at the Lawrence Hall of Science, in Berkeley, California. (See <http://lhsfoss.org>) The 3rd grade FOSS program, for example, consists of four units. Capital City's 3rd graders, however, missed two of those units completely and experienced only selected parts of the other two units. Students in many other grades were similarly deprived. If the school were to give science the dedicated time that it deserves, then students could experience the FOSS units as they are designed to be experienced, and students could cover the full FOSS program.

In light of the relatively small amount of time that 8th graders at Capital City PCS have spent doing science over their decade of schooling in grades pre-K through 8, we were not surprised that two-thirds of them failed the DC-CAS science examination. (April 2008 test; not a single 8th grader was "advanced" in science.)

Statements like, "We're not doing science this week," should be as rare in science as in math or reading -- the two subjects that the government has been using to rate schools. When our committee asked a Capital City PCS administrator about the results of the science section of the DC-CAS examination, she said, "It's never going to be a high-stakes test." While science may not be a high-stakes subject for the school, it is for the students.

The District of Columbia Public School system encourages schools to give students a minimum of 3.75 hours per week of science instruction in the upper elementary grades. (Washington Post, 27 October 2008, page B2.)

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2. The school should have a plan for science instruction, as it has for other subjects. Such a plan, known as a "scope and sequence" or "continuum," would prescribe the science knowledge and skills to be taught in each grade. The plan should be at least as comprehensive as the Massachusetts scope and sequence for science and should promise students hands-on experience with a large number of natural phenomena.

Capital City PCS opened in 2000 but did not begin to write a scope and sequence for science until summer 2009, following the formation of our committee, which is the first parent initiative at the school seeking improvement in the science instruction. The school has scope and sequence documents for subjects such as writing, math, and social studies.

The science curriculum should be a logical sequence of topics that are revisited repeatedly, in increasing depth, over the years. The school is on track to complete its new pre-K to 8 science scope and sequence in time to put it into effect beginning on 1 September 2009. The school should make sure that this schedule does not get pushed back.

The school uses the scope and sequence, or continuum, as a master plan to write more detailed instructional plans called "Curriculum Frameworks" and "Curriculum Maps." When this writing is done for science, it should be done by people with deep science knowledge.

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3. Teachers should receive a substantial amount of professional development in science and mathematics aimed at increasing their subject-matter knowledge.

One of the pleasures of doing research for our committee was going into classrooms and observing Capital City's skilled and dedicated teachers at work. (This is something that all parents can and should do.) The teachers are good at what they do: They can find ways to teach anything that they know.

This implies that the school's efforts to improve teaching would be much more fruitful if they focused more on adding to teachers' subject-matter knowledge than on adding to their repertoire of teaching techniques. Yet the school's weekly professional development (teacher education) efforts have emphasized pedagogy over deepening subject-matter knowledge. When our committee asked the head of school how many of the Wednesday afternoon professional development sessions this year involved hands-on science, she replied, "Not many."

The common assumption that adults know enough science and math to teach elementary school students such as first graders, second graders, and so on, is incorrect. Deep subject-matter knowledge makes a world of difference in the quality of instruction. This was shown powerfully by National Mathematics Advisory Panel member Liping Ma in her landmark book, *Knowing and Teaching Elementary Mathematics*. (The school should purchase multiple copies of this book and make sure that every teacher and administrator reads it.) The NMAP concludes that "teachers must know in detail and from a more advanced perspective the mathematical content they are responsible for teaching and the connections of that content to other important mathematics, both prior to and beyond the level they are assigned to teach."  
(<http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf> page xxi.)

Thus, NMAP member Vern Williams, a longtime middle school teacher in Fairfax County, Virginia, calls for schools to "Give the veteran teachers real inservice [training] involving real math content instead of force feeding them the newest teaching methods."

(<http://www.edweek.org/ew/events/chats/2009/05/05/index.html> at 2:52 PM) Tom Fortmann, a mathematician on the Massachusetts Board of Education, addressed the NMAP and quoted American humorist Will Rogers: "You can't teach what you don't know, any more than you can come back from where you ain't been." Fortmann said, "we need comprehensive professional development for current teachers; it must be rigorous; and it must be

challenging and extensive." (U.S. Department of Education, transcript of NMAP meeting of 14 September 2006, pages 34-38, <http://www.ed.gov/about/bdscomm/list/mathpanel/3rd-meeting/transcript0914.pdf> )

Trainers from the FOSS organization, from which the school gets kits that it uses for science instruction, should be invited to the school.

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4. Students in grades pre-K through 6, and their teachers, would benefit by working with specialist teachers who have deep science and mathematics knowledge. Resource teachers with such knowledge could team with teachers to prepare and deliver lessons and could lead in-service courses for teachers.

The National Mathematics Advisory Panel notes that "The use of teachers who have specialized in elementary mathematics teaching could be a practical alternative to increasing all elementary teachers' content knowledge (a problem of huge scale) by focusing the need for expertise on fewer teachers."

(<http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf> page xxii)

At the elementary school level, Capital City PCS has specialist teachers in such subjects as drama, art, music, and Spanish, and could do so in science and mathematics, too. John Eaton Elementary School, which is part of the District of Columbia Public School system, has a science resource teacher. At E. L. Haynes PCS in Washington, D.C., beginning in 4th grade, students have a teacher who focuses exclusively on science and math instruction at a single grade level, although not all of these teachers majored in science or math in college, because elementary school teachers with those majors are hard to find. The private Norwood School in Bethesda, Maryland, has specialist science teachers. Norwood students in grades 3-6 get four science periods per week; students in grades 7-8 get five. As a first step toward developing a strong science program, Capital City PCS should make its science program as good as the program at one of these schools.

Running a strong science program in the 7th grade or 8th grade requires a focused effort. So the school should consider having a science teacher for each of those grades. Co-teaching arrangements that bring together Lower School and Upper School science teachers for each of those grades might lead to better science instruction than the present arrangement, which pairs science and math instructors as co-teachers in grades 7 and 8.

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5. The school should offer a rigorous algebra 1 course.

When asked if its 8th grade math course is algebra 1, the Lower School answers yes. People ask because the answer is not obvious and the course is not called algebra 1 in school publications or on the 8th grade weekly schedule. The Upper School calls its algebra 1 course algebra 1. The Lower School should do so, too, as a sign of its commitment to offering a rigorous algebra 1 course.

In the Lower School, the course uses the Connected Mathematics Project (CMP) 8th grade program, in which the students work through eight booklets on various math themes. (<http://connectedmath.msu.edu>) CMP does not claim to be a complete algebra 1 course. It says, "Students who have been successful in the CMP algebra units will have met and mastered many of the ideas and skills that are part of a traditional Algebra 1." Schools that want to offer a complete algebra 1 course "may create a short 'patch' which can be added to the 8th grade CMP units." (<http://connectedmath.msu.edu/implement/high.shtml>) If such a "patch" exists at Capital City PCS, there is no evidence that it is being used or that teachers trying to get through all of the CMP booklets would even have time to use it.

In surveying a wide variety of schools during the 2008-09 school year, we didn't find any other schools that use CMP for algebra 1 -- not even the Capital City PCS Upper School. The surveyed schools use textbooks that cover the subject more comprehensively and, unlike the CMP booklets, contain worked-out examples. The following is a list of algebra 1 textbooks used by selected schools...

**FAIRFAX COUNTY PUBLIC SCHOOLS (Virginia)**

**Algebra 1**

**McDougal Littell (Houghton Mifflin)**

**ISBN-13: 9780618594023**

**ISBN-10: 0618594027**

**Glencoe Algebra 1**

**Glencoe (McGraw-Hill)**

**ISBN-13: 9780078738227**

**ISBN-10: 0078738229**

**SIDWELL FRIENDS (Washington, D.C.)**

**Algebra I -- An Integrated Approach**

**McDougal Littell (1995)**

**ISBN-13: 9780812387513**

**ISBN-10: 0812387511**

**GEORGETOWN DAY SCHOOL (Washington, D.C.)**

**MIDDLE SCHOOL (7th or 8th graders):**

**Algebra I -- An Integrated Approach**

**Charles Hamberg, George Milauskas, John Benson, Sara Dodge, Walter Dodge, Richard Rukin**

**McDougal Littell (1998)?**

**HIGH SCHOOL (9th graders):**

**Algebra 1**  
Holt McDougal (2004)  
ISBN-10: 0030700396  
ISBN-13: 9780030700392

SCHOOL OF THE FUTURE (New York, N.Y.)  
Integrated Algebra, New York edition  
Prentice Hall (2008)  
ISBN-13: 9780133657876  
ISBN-10: 0133657876

"We like the book because it does have a lot of real world applications and it has questions specifically earmarked as critical thinking, skills practice, writing, open-ended, etc. In addition, the set comes with about two large boxes of manipulatives that go along with various chapters."

HOMESTEAD HIGH SCHOOL (Cupertino, California)  
Algebra Connections, volumes I, II  
CPM Educational Program (Sacramento, California)  
National Edition Version 3.1 (2006)  
ISBN-10: 1931287457  
ISBN-13: 9781931287456

CAPITAL CITY PCS (Washington, D.C.)  
UPPER SCHOOL  
Discovering Algebra: An Investigative Approach, second edition  
Key Curriculum Press (2007)  
721 pages  
ISBN-13: 9781559537636

DISTRICT OF COLUMBIA PUBLIC SCHOOLS  
Algebra 1 (Equations, Graphs, Applications)  
McDougal Littell (2004)  
ISBN-10: 0618250182  
ISBN-13: 9780618250189  
It is a typical algebra 1 textbook; the full text is available on-line at  
[http://www.classzone.com/books/algebra\\_1/index.cfm?state=DC](http://www.classzone.com/books/algebra_1/index.cfm?state=DC)  
Click on "Online Book"  
Click on "Student Login"  
Enter username: "capcity"  
Enter password: "algebra"

For its Lower School algebra 1 course, Capital City PCS should seriously consider using a textbook with "algebra" in its title, such as one of the books listed above. Using a comprehensive algebra 1 textbook is the only practical way for the school to ensure that its algebra 1 course has the right scope and pace. (Alternatively, the school could recruit mathematicians or scientists to teach the course, in which case any textbook, or even no textbook, would be fine.) To ensure that the

course has sufficient depth, the school should make sure that teachers supplement the textbook with challenging problems from the 8th grade Connected Mathematics Project booklets, which contain many excellent questions. The school should continue to use CMP in grades 6 and 7.

In selecting a textbook for algebra 1, the school should keep in mind the words of National Mathematics Advisory Panel member Vern Williams, who warns parents to be suspicious of textbooks that claim to teach "algebra for all." Williams says: "The 'all' tells me that the textbook is for students who are not prepared for a real algebra course." (Washington Post, 29 September 2008, page B2.)

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6. The school should allow -- indeed, encourage -- acceleration in mathematics, as it does in reading. ("Acceleration" means moving through the curriculum at a faster pace.)

Capital City PCS allows capable students to accelerate in reading, but not in math. Studies show that students who are capable of acceleration can cover the material in greater depth, too. The National Mathematics Advisory Panel found that, "students who are advanced in their skill and concept attainment and can learn new material at a much more rapid rate than their same-age peers ... need a curriculum that is differentiated (by level, complexity, breadth, and depth), developmentally appropriate, and conducted at a more rapid rate."

(<http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf> page 53) Will Capital City PCS meet that need?

Allowing students to accelerate in math "is increasingly common in Washington area schools, with a growing share of students working two or more years ahead of their grade." (Washington Post, 4 June 2008, page A10.) The Montgomery County, Maryland, school system, for example, allows students to accelerate in math beginning in kindergarten, and many students are completing the 6th grade math curriculum by the end of 5th grade. The system has made 6th grade math available in all elementary schools.

(<http://www.montgomeryschoolsmd.org/info/keys/key3.shtm> Washington Post, 18 May 2009, page B2, item 3. See, also, Washington Post, 18 June 2009, District Extra, page 6.) The fraction of students taking algebra 1 in 7th grade is increasing rapidly in Fairfax County, Virginia, and in Montgomery County, Maryland. (Washington Post, 4 June 2008, page A10.)

Alice Deal Middle School, a DCPS school in Washington, D.C., had twelve algebra 1 classes in the 2008-09 school year. Five of these classes were 7th graders; the other seven classes were 8th graders. Interestingly, the 7th graders outperform the 8th graders in algebra.

The above reports from other schools lead us to believe that a significant number of Capital City PCS students, too, would accelerate in math if the school permitted them to do so. In an informal,

unscientific survey, we asked Capital City PCS teachers (and in one grade a student) for rough estimates of what fraction of students grasp new math concepts quickly, what fraction take the allotted time, and what fraction need extra help. Here are the estimated fractions of students who grasp the concepts quickly...

1st grade 58%  
2nd grade 33%  
3rd grade 25%  
4th grade 08%  
5th grade 20%  
6th grade 25% (Lower School)  
6th grade 16% (Upper School)

It appears that a significant fraction of Capital City PCS students could, for example, easily complete pre-K through 7th grade math by the end of 6th grade.

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7. In its publications that discuss its curriculum, the school should list calculus explicitly as a course that it plans to offer.

The Upper School parent handbook lists "Precalculus or Advanced Placement course" as the highest math course to be offered by the school.

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8. Technology is an important subject that deserves greater representation in the curriculum, with an explicit continuum (scope and sequence) of its own. Students should be able to explain in detail how things work.

The school is developing a technology continuum as part of its summer 2009 science continuum effort.

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9. The Everyday Mathematics program, which the school uses through 5th grade, provides a "Family Letter" for teachers to photocopy and send home at the beginning of each unit during the school year. The letter tells parents what math their children will be learning in the unit. The school should make sure that these letters are sent home.

Parents should be kept well-informed about classroom plans.

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10. The school should incorporate the above recommendations into its forthcoming School Improvement Plan, and make sure that the plan includes science.

The overall mathematics proficiency rate of Capital City PCS students dropped by 10 percentage points during the 2008-09 school year as measured by the April 2009 DC-CAS examination, and the school did not make Adequate Yearly Progress as defined by the No Child Left Behind law.

As noted in the discussion of recommendation 1 above, while science may not be a high-stakes subject for the school, it is for the students. It should therefore be part of the school's improvement plan.

Alex Harris, Assistant Superintendent of Assessment and Accountability at the D.C. Office of the State Superintendent of Education, told us that science may be included in a School Improvement Plan. He said that doing so would be "a nice complement" to the legally required material, showing that the school has a broad focus.

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